EFFECTS OF MEMORY GAMES ON LONG-TERM LEARNING

By

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ABSTRACT

The brain may benefit from mental preparation before learning new information in order to maximize retention (akin to warm-up exercise for the body). Prior research has found that this type of engaging mental preparation can improve memory, but it has not been contrasted against less engaging mental preparation. In one experiment, participants were asked to engage in one of three mental activities prior to watching a video lecture: 1) play a memory game on easy difficulty, 2) play the same memory game on challenging difficulty, or 3) complete an online coloring task (baseline). All participants were given a multiple-choice exam 48 hours later on the contents of the lecture. We hypothesized that the participants in the challenging memory game condition would have the best memory performance of the three groups because prior work has shown that mentally stimulating activities can prime the brain to receive information. Less engaging/challenging tasks may not have the same effect. A one-way ANOVA did not detect a significant difference in memory performance between the three groups. However, this null finding may be due to constraints of the study. Due to COVID-19 restrictions we were required to conduct the experiment through Zoom, which reduced our ability to monitor participants' attention to the lecture video and engagement with the tasks—a critical component of the study. Future work will be required to determine whether mental preparation can benefit learning.

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INTRODUCTION

Most people spend a large portion of their life in school, which requires them to remember a massive amount of information over the span of 12 or more years. Learning and remembering information from even one class can be a struggle for many students. Even if the student is able to understand the material from the lecture, they will still forget much of it and need to learn it again in future courses and/or in their careers. Finding strategies to absorb and preserve information from a class lecture quickly may help students retain information for longer periods of time. There are many techniques used in learning environments to help facilitate learning, which include the use of memory games. Past research has tested the effects of memory games on short-term learning but there are relatively fewer studies that discuss its use in long-term learning of ecologically-valid course materials. The present study will research if the use of memory games can improve long-term memory of lecture content in college students.

In learning environments, like school lectures, distraction and fatigue are common impediments to long-term learning. Studies have found multiple factors that contribute to mind wandering and loss of focus during lectures. A recent study by Kane (2021) identified the traits, attitudes, and habits are related to students' task-unrelated thoughts (TUT) during lecture. The researchers found that mind wandering could be attributed to external predictors; for instance, seat location, time spent in lecture, and time of lecture. The amount of mind wandering was different from person to person but the trajectory was, on average, consistent: there was an increase in TUTs per student over time during the lecture. However, these predictors are almost nonexistent in an online format, with classes being recorded allowing students to watch at their own pace and time. According to the study, students' focus could still be predicted based on internal factors such as their level of interest in lecture material, understanding, and note taking habits. These were found to be possible predictors for online courses but were not as reliable as the external predictors. This study's separation between online and in-person classroom habits is important because in recent years the education environment has shifted to a mostly online format, and students may find themselves struggling to stay focused and retain information in online lectures. Whatever the reason for waning focus during lectures, it is important to try to engage students' attention and promote learning as much as possible. One strategy many classrooms are using to hold the students' attention is teaching through online interactive games.

Games have become a large part of society and are available in all forms and to all audiences. Classrooms have begun to use educational games as a part of their lesson plans or use online activities as homework assignments. In these current times with schools being held remotely, educational games have become more common and appreciated (Thomas, 2022). One of the most common problems for struggling students is that they feel like they cannot stay focused long enough to retain all the information from lecture (Makin, 2016). However, video games have the ability to keep people entertained and focused for hours on end. They do this by using level-based designs, achievable goals, and a high quality production value in order to maintain intrigue (Clark, 2003). These same techniques can be used to help students stay on task and invested in what they are learning. One study by Klopfer (2009) stated that it is advantageous to incorporate educational games as a part of teaching the materials because games engage students and allow the teachers to leverage the learning without disrupting the flow of the lesson. Games also allow the students to make mistakes that they can learn from. Such play-based learning gives students the freedom to experiment and show effort in their learning without feeling pressured by the possibility of earning a potentially bad grade.

If the students are given the freedom to learn on their own and the learning is enjoyable, it can create a lasting focus and interest in the subject. Research by de Freitas (2018) compiled recent studies on educational games to see if the research confirms the notion that the use of games to teach is positive beyond mere student liking. Longitudinal studies confirmed an increase in brain volume and plasticity during play, indicating an increase in the efficacy of the participants' learning (Kühn, 2014). They also used randomized trials to compare games versus traditional methods, which confirmed that educational games can be more effective than the traditional model of lecturing and take-home work. Educational games can help students achieve the same level of understanding by creating engaging games that complement the lecture (de Freitas, 2018). However, the brain is a complex organ and executive and cognitive functions needed for learning can be influenced by multiple factors.

One such factor is cognitive functioning, which is an umbrella term that encompasses learning, attention, thinking, and other executive functions. These cognitive skills are required for long term learning and attention, and can be improved through the use of games to promote mental exercise (Understood.org, 2022). Researchers have begun to notice that video games can have an effect on individual executive functions and recent studies have tested how this occurs. Nouchi (2013) studied how executive functions, such as memory and processing speeds, can be strengthened through the use of brain training games. He hypothesized that different video games would improve different cognitive functions, but stated that previous studies found that not all games produced positive results in functioning. For this reason they compared performances of a brain training game, *Brain Age*, and a non-brain training game, *Tetris*. Results suggested that the game *Brain Age* had a significant positive effect on working memory and other cognitive functions in healthy young adults when compared with *Tetris* players (Nouchi, 2013). This suggests that there are beneficial effects of using brain training games to improve aspects of memory, however their research focused on increasing working memory (WM; the ability to hold and manipulate a limited amount of information in mind; Aben, 2012). Increasing WM is only a small part of learning. In a classroom environment, it is important that students are not only able to manipulate information in mind, but are also able to a) transfer information to long-term memory (LTM), and b) to retrieve that information from long-term memory when it is needed (e.g., on an exam). Previous studies have researched ways of strengthening the connection between WM and LTM through the use of cognitive exercises.

A study by Jaeggi (2011) performed a noninvasive experiment to test the effects of cognitive exercises when performed by young students. Specifically, this study tested whether working memory can be enhanced through the use of memory tasks in elementary and middle school students. An experimental group and an active control group were compared to test the cognitive enhancement of memory games. The active control group was given an exam that tested them on general knowledge and vocabulary. In contrast, the experimental group completed a memory task where they were presented with multiple variations of a picture and asked if an item in a picture appeared in the previous stimuli (i.e., a WM training game). The researchers also wanted to test if the amount of training was equivalent to the amount of improvement so they split the experimental group into a small and large training group. Both groups were administered the same tasks but the small training gains group (STG) was given less time with the memory tasks than the large training gains group (LTG) in order to see if the amount of improvement in memory directly correlated with the time spent in training through memory games. The memory tasks were administered electronically and resembled a video game in order to keep the students engaged.

The results of this study showed improvement in the experimental group but no significant improvement in the active control group. The most interesting finding was that the STG group showed very little improvement but the LTG group had significant improvements between the first two sessions and the last two sessions of the activity. In contrast there was no difference in the active control group and the STG group. The researchers presumed that the significant increase in development for some students and not others could be attributed to some students having a deficit in working memory allowing for greater availability for improvement. The researchers suggested that the level of improvement is conditional on the individual's limitations and each person will respond differently to the cognitive exercises.

Since this study was conducted on elementary and middle school students, it is possible these findings could be age specific and may not apply to college students. Jaeggi expanded on previous research by testing the working memory of young students instead of college students; however she did not address any classroom applications of the cognitive exercises nor how long learned information could be retained in their long-term memory. This idea of using educational games to facilitate learning in real life classrooms is expanded upon in newer research.

It is important to test research findings in ecologically valid settings to ensure that the findings can be consistent with students learning in live lectures. As mentioned above, mind-wandering and fatigue are problems all students encounter during lectures and can affect their response to brain training games. Mind wandering and fatigue may be more prevalent in a lecture setting than in a brief in-lab experiment like those previously described. White & Highfill (2019) examined the effect of cognitive exercise on undergraduate students' executive functioning in a lecture setting across an entire semester. Executive control refers to the individual's ability to regulate their own thoughts, and executive functioning is one's ability to sustain their thoughts in order to process it in their working memory (Zelazo, 2017). It was suggested that using cognitive exercise would strengthen executive controls and have a significant reduction effect on mind wandering and induce a focused state of mind. This would allow students to consolidate more information because their working memory is active as long as their attention is sustained on the lecture. On half of the lecture days, students were given a cancelation task that involved canceling out a specific symbol from a large grid filled with related symbols. Students had to quickly scan through the rows of related symbols to mark out all instances of the designated target. On the other half of the days, students did not complete this cognitive exercise activity–they proceeded with the lecture as normal. Exam performance at the end of the term was higher for questions associated with exercise days compared to non-exercise days. Students also reported an increase in alertness during lectures when they completed the cognitive exercise. While these results are significant it is important to understand the limitations of this study. For instance, when students completed the cancelation task prior to lecture, they might have presumed that their focus would be enhanced during lecture, thereby creating a placebo effect on training students. There was also no way to monitor students' mind wandering during lecture but the researchers suggested the use of mind-wandering probes for future experiments. Researchers also believed that the instructor was not blind to the study and thus may have shown bias when lecturing to the cognitive exercise students. Despite the limitations of the study, it is still important to acknowledge the significance of its findings. The cancellation task was not related to lecture material, so it did not give extra material to help students on the exam. This means that, in theory, a cognitive exercise task like this could be applied to any subject of any college level and produce similar results. One aspect that this study did not test was how this would transfer over to an online setting. Due to COVID-19 many classrooms struggled to shift to an online teaching format and thus the nature of how students attend lectures has changed. Thus, additional work is needed to understand the effects of cognitive exercise/memory games on students' long-term learning of lecture content–particularly in online environments.

The Present Study

The present study acknowledges the current shift towards online learning and tests how cognitive exercises can affect student learning during online lectures. This is important because while students may have adapted to learning online, the teaching methods have generally stayed the same with the exception of being held over Zoom. Introducing new teaching techniques, such as a memory game that may increase student focus on the upcoming lecture, may help students struggling to acclimate to the online environment. The present study tested the effects of memory games on long-term learning by applying a 48-hour day delay between learning and testing. We also incorporated two difficulty levels of the memory game (easy and challenging) in order to see if students needed to be challenged by the game in order to receive its benefits. Based on the research that demonstrated that memory games can strengthen executive functioning to help participants recall information (White & Highfill, 2019), we hypothesized that playing a memory game immediately before learning would improve long-term memory recollection for lecture content administered 48 hours later. Additionally, we predicted that the game would need to be challenging in order to yield the greatest benefit, as they might otherwise be prone to mind wandering with an easy task (White & Highfill, 2019).

Methods

Participants

A total of 115 participants were recruited from the University of California, Riverside SONA participant pool. Twenty-eight participants were excluded for failing to complete the study or already being familiar with the experimental materials. This resulted in a final sample of 87 undergraduates. Participants received 0.5 credits for each of two day they attended, totaling to 1 credit for completing the study and 1 hour of participation over a 48 hour period. SONA credits are used to fulfill class requirements. Participants were given a consent form to sign prior to participation and would provide their age, gender, class standing, and major. These demographic data were not analyzed since they were not related to our hypothesis.

Design

This study had three independent groups (pre-lecture task: difficult memory game vs. easy memory game vs. coloring control). The dependent variable was participants' scores on the 16-question multiple-choice quiz. This study used a one-way ANOVA in order to compare the means of the three groups to determine if there was a significant effect of the pre-lecture task on memory performance two days after learning.

Materials

The experiment was held online and required the participants to have a stable internet connection and a suitable device that can access videos and had a working camera. The easy and challenging memory tasks were played on a website called *Helpful Games* (https://www.helpfulgames.com/subjects/brain-training/memory.html) and the coloring activity was played on a website called *Coloring Online* (https://www.coloringonline.com/). The Challenging group played a memory matching game that had 36 cards in a 6x6 grid. All cards were face down and the participants would attempt to match all 18 combinations by flipping two cards at a time. There was no limit to the number of tries they had per game or the number of times they played the game; instead, time playing was controlled by ensuring that each participant played for a total of 10 minutes. The Easy group played the same game for 10 minutes but instead matched 20 cards in a 4x5 grid. The Control group was given an online coloring activity where they would choose an uncolored picture and fill it in for 10 minutes.

The lecture video was taken from a YouTube channel called *Extra Credit* and the video was titled Cheng I Soa (https://youtu.be/-p2lhxUqMMQ). The video was a condensed animated story of the life of a Chinese Pirate. This was chosen to be the lecture video because it was only about 10 minutes, well animated, and had a simple premise that did not require the participants to have any previous knowledge in order to follow the story. It is also not one of the YouTube channel's most popular videos so it was unlikely that the participants would have seen it, although it did happen on one occasion (this participant was excluded).

The final memory quiz consisted of 16 multiple-choice questions on information taken from the Cheng I Soa video. The questions asked about information that was either said by the narrator or shown on the screen. Some questions tested participants on their ability to recall numbers, such as "How many individual fleets of pirates served in the original confederation?" (Answer: 6). Other questions tested them on their ability to recall moments in the narrative, "What did Cheng do after the war?" (Answer: Run a gambling house in Canton). Participants were allowed unlimited time to complete the quiz but most finished in approximately 10 minutes.

Procedure

The study occurred on two days separated by 48 hours. On Day 1, the participants were assigned into one of the three conditions based on the order in which they signed up (i.e., Participant 1 in Condition 1/Easy Game, Participant 2 in Condition 2/Difficult Game, Participant 3 in Condition 3/Coloring control, etc.). Before beginning the experiment, the participants were asked to provide their age, gender, class standing, and major. After completing the activity that corresponded to their condition (i.e., Challenging, Easy, or Coloring), each group watched the lecture video titled Cheng I Soa by *Extra Credit*. The participants were advised to focus on the video as they would be tested on its content during Day 2 and would not be allowed to take notes. This concluded Day 1.

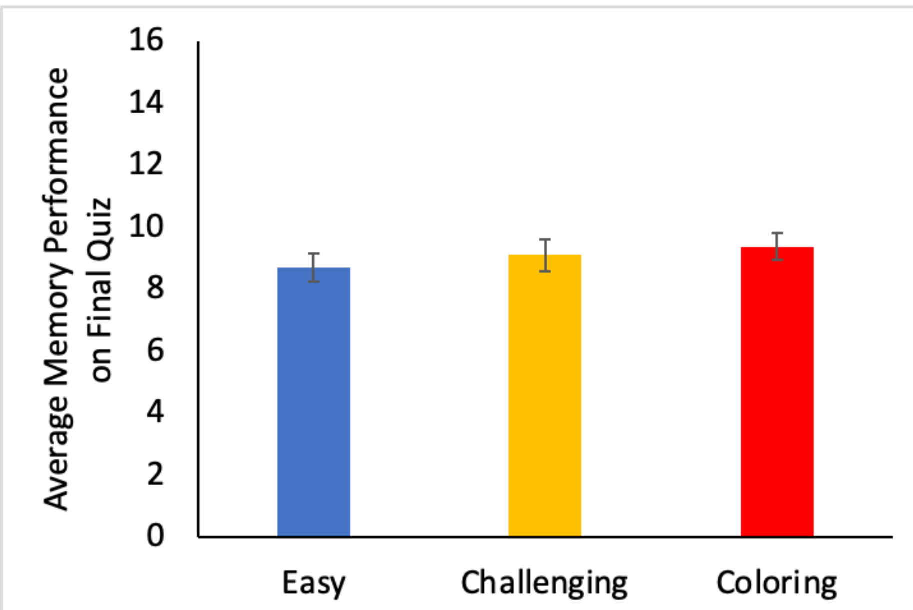
Forty-eight hours later the participants returned to complete the final memory quiz on information discussed in the lecture video. Participants were closely monitored across both days by a research assistant over Zoom, to avoid any instances of cheating and/or distractions. Participants were told to keep their camera and microphones on and to share their screen during the task, lecture, and quiz portions, although due to technical difficulties some participants were permitted to have their camera off and not share screens. After completing the memory quiz, the participants were asked three questions about their experience of the game, lecture video, and quiz. Specifically, they were asked to rate the difficulty of the exam on a scale from 1-10, report whether they struggled with any aspect of the exam, and if they felt the activity they played before watching the video helped in any way. Finally, they were read a debriefing form that explained the purpose of the research and were thanked and compensated for their participation.

Results

The test scores from Day 2 were averaged into three separate categories based on the three independent groups. Participants in the Easy Group averaged 8.71 (SD = 2.4), participants in the Challenging Group averaged 9.1 (*SD* = 2.7), and participants in the Coloring Group/Control averaged 9.38 (*SD* = 2.4) out of a possible 16 points (See Figure 1). A one-way between-subjects ANOVA failed to reveal a significant difference in test scores between those who played a memory game before learning (on either difficulty) and those who participated in the coloring activity, $F(2, 86) = 0.51$, $p = .60$.

Figure 1

Memory Performance as a Function of Condition



Note. Error bars represent 1 standard error.

Discussion

The goal of this study was to determine if the use of a memory game before learning helped improve long-term memory for lecture content. Based on prior work, we hypothesized that playing a memory game immediately before learning would improve long-term memory recollection for lecture content (i.e., two days later). This hypothesis was based on previous research that concluded that memory games can strengthen executive functioning to help participants recall information (White & Highfill, 2019). We also believed that the challenging difficulty level of the game would yield the highest performance because previous literature stated that students would need to be engaged for the information to be encoded by their WM (Aben, 2012). The Easy and Coloring Control groups were designed to be too simple to sustain participant attention and therefore would not consolidate as much information into their LTM as the Challenging group. However, we failed to find a significant effect of memory games of either difficulty on learning compared to the control.

We may have failed to find a significant difference between the three groups because of other factors affecting memory performance. One such factor is “flow” (Csikszentmihalyi, 2016). The theory of “flow” is that a person can become fully immersed in the activity they are performing to create a state of focus. Flow is thought to occur when the subject is performing a task that stimulates them either physically or mentally. However, the activity does not always have to be challenging for someone to achieve flow. For instance, if the activity is easy to complete but the subject is enjoying it then they can still be focused enough to enter into a flow state. The researchers observed this possible phenomenon in participants playing the coloring game. They seemed to be immersed in their task more so than the other groups, and many stated afterwards that they felt this focus created by the coloring activity continued when they stopped coloring to watch the video. This may have increased the memory performance of the control group in ways that we did not predict compared to the memory games. We can examine the effect of flow on memory performance in future studies about memory games.

Previous literature would suggest that educational games have a positive effect on student memory; however, our study was different from this prior work in a number of key ways. White and Highfill (2019) performed a very similar study to this one but instead had students complete the game (i.e., the cancelation task) multiple times over the course of a few weeks, whereas this study only allocated a single session per participant. Our study design allowed the researchers to test more participants in a shorter amount of time but sacrificed student comprehension since they were only permitted to view the video once before the exam. However, our results build on existing evidence by suggesting that in order for memory games to have an effect on cognitive functioning they may need to have multiple implementations across multiple days. This could be seen in the work by Nouchi (2013), White and Highfill (2019), and Jaeggi (2011) which required participants to play the games multiple times. Both found a significant effect of memory games on learning. An important detail of these two studies that was similarly replicated in the present study was the use of the delay between learning and testing. This is important because most research done on memory games and learning studied short term memory, however in a real life classroom, LTM is used more frequently.

Limitations

There were limitations that affected the present study. The most notable limitation of this study is that it was forced to be conducted online due to COVID-19 (though we were interested in understanding how memory games might impact online learning given the circumstances). While we adapted the study to be implemented online and took precautions to ensure that participants were properly engaging with the study, it was still challenging to remove distractions for participants during learning and testing. It also meant that researchers could not control the setting that participants would be in for the first and second days. A potential change in location from Day 1 to Day 2 could have affected the study because memory can be context-dependent, meaning that information is easier to recall in the location that it was encoded (Mcleod, 2021).

This adds an unintentional third variable because the participants who were in the same location during the exam and learning phase may have had an easier time recalling the information than the participants who switched locations.

Other inconsistencies between participants include different sound and video qualities, the presence of advertisements in the middle of the video for some but not all participants, and monitor sizes/device differences. Performing the task on a phone can be difficult because the rows and columns for the memory task will look more condensed, making it harder to distinguish between them. It will also make it more difficult to notice the details of the lecture video which are important for the quiz. All the quiz questions were spoken out loud but some were said very quickly and without the visual aid it is possible to miss it. This creates an advantage to those with larger monitor sizes. Low sound and/or video quality will also make it more difficult to hear the details of the video. Sudden advertisements can distract the participants and when the video returns they may no longer be in a focused state, negating the effects of their task. Additionally, all participants were asked to complete the learning phase on a computer but due to technical difficulties some participants were permitted to complete both or one of the days on their phone. Compounding these differences in the way the participants were tested creates a different experience for each participant in ways that are not true of in-person lectures (but may be true of online classes). These inconsistencies across participants could be avoided when testing in-person and should be taken into account for future studies.

Although the study failed to find a significant effect of memory games on learning, the results of this study can still have implications for future research. Previous research mainly tested the effects of memory games on short term learning and the few that tested long-term learning used generic learning tasks to prime the brain (Jaeggi, 2011). Future studies should move beyond using generic games by creating a memory game that is designed to engage the student by using material that is similar to what they will be learning in lecture. For example, if the lecture is a math class then the educational game could quiz the students on simple math equations from previous lectures. This would provide them with a review of previously learned material but also prime the brain to encode similar information. Creating a memory game tailored to the lecture material would build upon previous research and also imitate what a real world application of this research would look like.

Concluding Comment

Though this study did not yield significant findings, it did highlight the struggles of online learning. All the limitations that hindered this experiment are also problems that occur during real life lectures and can negatively influence student learning. If students are transitioning to learning online then the material presented to them must also accommodate such changes. Research has demonstrated that educational games can improve memory; thus future studies should explore the limits of that improvement and how to effectively use educational games to complement the material in order to maximize long term learning.

References

Aben, B., Stapert, S., & Blokland, A. (2012). About the distinction between working memory and short-term memory. *Frontiers in Psychology*, *3*, 301. https://doi.org/10.3389/fpsyg.2012.00301

Clark, D. (2003). Games and e-learning. Epic Group.

Csikszentmihalyi, M. (2016). Attention and optimal functioning. In *Flow and the foundations of positive psychology*. Springer.

DeVries, D. L., & Edwards, K. J. (1973). Learning games and student teams: Their effects on classroom process. *American Educational Research Journal*, *10*(4), 307-318.

De Freitas, S. (2018). Are Games Effective Learning Tools? A Review of Educational Games. *Journal of Educational Technology & Society, 21*(2), 74-84. Retrieved March 9, 2021, from http://www.jstor.org/stable/26388380

For learning and thinking differences. Understood. (2022). Retrieved April 11, 2022, from https://www.understood.org/

Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Shah, P. (2011). Short- and long-term benefits of cognitive training. *Proceedings of the National Academy of Sciences*, *108*(25), 10081–10086. https://doi.org/10.1073/pnas.1103228108

Kane, M. J., Smeekens, B. A., Von Bastian, C. C., Lurquin, J. H., Carruth, N. P., & Miyake, A. (2017). A combined experimental and individual-differences investigation into mind wandering during a video lecture. Journal of Experimental Psychology: General, 146, 1649. doi:10.1037/xge0000362

Klingberg, T., Forssberg, H. & Westerberg, H. *J. Clin. Exp. Neuropsychol. 24*, 781–791 (2002).

Klopfer, E., Osterweil, S., & Salen, K. (2009). Moving learning games forward. *Cambridge, MA: The Education Arcade*.

Kühn, S., Romanowski, A., Schilling, C., Lorenz, R., Mörsen, C., Seiferth, N., Banaschewski, T., Barbot, A., Barker, G.J., Büchel, C., & Conrod, P.J. (2011). The Neural basis of video gaming. Translational Psychiatry, 1(11), e53.

Kühn, S., Gleich, T., Lorenz, R. C., Lindenberger, U., & Gallinat, J. (2014). Playing Super Mario induces structural brain plasticity: Gray matter changes resulting from training with a commercial video game. Molecular psychiatry, 19(2), 265-271.

Mcleod, S. (2021, March 4). *Context and state dependent memory*. Context and State Dependent Memory | Simply Psychology. Retrieved May 1, 2022, from https://www.simplypsychology.org/context-and-state-dependent-memory.html

Makin, S. (2016). Brain training: memory games. Nature, 531(7592), S10-S11.

McLeod, S. A. (2010, December 14). *Long-term memory*. Simply Psychology. https://www.simplypsychology.org/long-term-memory.html

Meeter, M., & Murre, J. M. (2004). Consolidation of long-term memory: evidence and alternatives. Psychological Bulletin, 130(6), 843.

Morra, S., & Camba, R. (2009). Vocabulary learning in primary school children: Working memory and long-term memory components. Journal of experimental child psychology, 104(2), 156-178.

Nouchi, R., Taki, Y., Takeuchi, H., Hashizume, H., Nozawa, T., Kambara, T., ... Kawashima, R. (2013). Brain training game boosts executive functions, working memory and processing speed in the young adults: A randomized controlled trial. PloS One, 8, e55518. doi:10.1371/journal.pone.0055518

Souza, A. S., & Oberauer, K. (2017). Time to process information in working memory improves episodic memory. Journal of Memory and Language, 96, 155–167. https://doi.org/10.1016/j.jml.2017.07.002

Thomas, A. (2022, February 2). *5 reasons video games should be more widely used in school*. Texas A&M Today. Retrieved May 1, 2022, from https://today.tamu.edu/2021/09/06/5-reasons-video-games-should-be-more-widely-used-in-school/

White, H. A., & Highfill, L. E. (2019). Cognitive exercise boosts exam performance in an introductory psychology course. *Teaching of Psychology*, *46*(2), 135–139. https://doi.org/10.1177/0098628319834196

Williams, A., Birch, E., & Hancock, P. (2012). The impact of online lecture recordings on student performance. *Australasian Journal of Educational Technology*, *28*(2). https://doi.org/10.14742/ajet.869

Zelazo, P. D. (2017). *National Center for Education Research (NCER) presentations and publications: Executive function: Implications for education*. Institute of Education Sciences (IES) Home Page, a part of the U.S. Department of Education. Retrieved May 1, 2022, from https://ies.ed.gov/ncer/pubs/20172000/